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## THE IMPACT OF DIGITAL TECHNOLOGIES ON THE DEVELOPMENT OF TRANSPORT LOGISTICS IN KAZAKHSTAN

**Abstract.** *The article addresses the issues related to the study of digital logistics and the analysis of the degree of implementation of modern technologies in the transport and logistics sector of Kazakhstan. The research is based on an assessment of the interconnection between technological readiness, innovation-driven development, and logistics efficiency. Since the late 1990s, when the concepts of internet technologies and the digital economy were first widely discussed, significant transformations have taken place, fundamentally reshaping business processes and consumer practices. Over more than two decades, digitalization has evolved into a crucial driver of competitiveness and efficiency in transport logistics.*

*Today, digitalization is no longer perceived as an innovative phenomenon but as a normative standard of industry development. Practical examples include electronic tickets, online passenger check-in systems, digital navigation platforms, and mobile applications for taxi services. These technologies, which once appeared unattainable, are now integrated into everyday logistics operations and consumer practices. At the same time, the ongoing digital transformation is increasingly oriented towards the adoption of advanced solutions, such as unmanned vehicles, intelligent traffic management systems, and smart transport infrastructure capable of monitoring compliance with traffic regulations.*

*Digital platforms are becoming a cornerstone of the modern global economy by ensuring transparency, accessibility, and efficiency of logistics chains. Their role is particularly significant in enhancing the integration of Kazakhstan's transport and logistics system into global supply chains, thereby supporting sustainable economic development and strengthening the country's transit potential.*

**Keywords:** *digital logistics, digitalization, innovation, transport infrastructure, freight transportation.*

### Introduction.

In the Republic of Kazakhstan, the “Digital Kazakhstan” state program is being carried out to accelerate economic development and improve the population’s quality of life through the introduction of digital technologies. In the medium term, the program is designed to modernize the national economy, while in the long run it seeks to form the foundation for a fully digital economic model [1].

The implementation of this initiative follows two main directions:

1. Digitalization of the current economy – this includes the launch of targeted projects in key industries, technological modernization of existing sectors, the adaptation of government bodies to digital tools, and the expansion of digital infrastructure.

2. Formation of the digital economy of the future – this involves long-term sustainability measures such as investing in human capital, developing institutions that promote innovation, and building an advanced digital ecosystem [2].

Globally, the defining trend of modern economic growth is the rising role of digital technologies. Digitalization is progressing rapidly, and no sector remains untouched by it. In transport logistics, recognizing current trends and applying them effectively helps businesses enhance efficiency, optimize costs, and strengthen competitive positions in the market.

The active diffusion of digital tools shapes both economic and social progress, while also transforming daily life. In logistics and transportation, digitalization has become a key driver of efficiency and competitiveness. Research by the International Transport Forum (OECD) shows that digital solutions can reduce transaction costs, improve transparency, and accelerate transport operations [2]. Since the end of the 1990s, when the internet and the digital economy began to expand globally, digital transformation has become a worldwide priority [3].

Examples of digitalization in transport already include e-tickets, online check-in, intelligent navigation systems, and electronic booking platforms. Future trends point toward the mass adoption of autonomous vehicles, smart road networks, and advanced traffic management systems [4]. For Kazakhstan, with its significant transit potential, the introduction of digital technologies is especially important, as it enables deeper integration into global transport and logistics chains.

The rapid development of digital technologies is reshaping the global transport and logistics industry, creating opportunities for cost reduction, real-time monitoring, and improved efficiency of supply chains [5]. For Kazakhstan, positioned as a strategic transit hub between Europe and Asia, the integration of digital solutions is a key factor in enhancing competitiveness in the global logistics market [6].

However, despite positive trends, the level of digitalization in Kazakhstan's transport sector remains limited. The country faces a set of systemic challenges, including insufficient technological readiness, shortage of qualified personnel, high financial requirements for digital transformation, and underdeveloped regulatory frameworks. These barriers prevent the full-scale implementation of digital platforms, Internet of Things (IoT) technologies, unmanned vehicles, and intelligent logistics systems, which are already being actively adopted in developed economies [7].

Thus, the central problem addressed in this article is the insufficient integration of digital technologies into Kazakhstan's transport logistics, which constrains the country's ability to realize its transit potential and strengthen its role in international supply chains. The objective of this study is to assess the impact of digital technologies on the development of Kazakhstan's transport and logistics sector, to identify the main barriers to their adoption, and to evaluate the economic potential of digital transformation.

The scientific novelty of the study lies in the development of a quantitative model for assessing the economic efficiency of transport digitalization in Kazakhstan. The practical significance is determined by the possibility of applying the obtained results to formulate state policy measures and corporate digital strategies.

The digital transformation of transport and logistics systems has become one of the central research directions in international academic discourse. A growing body of literature highlights that the integration of advanced digital technologies—such as the Internet of Things (IoT), Radio Frequency Identification (RFID), blockchain, cloud analytics, digital twins, and autonomous vehicles—has fundamentally reshaped the efficiency and resilience of global supply chains (Nguyen et al., 2022; Wang & Zhang, 2021; Deloitte, 2020) [4,6,7]. According to Waller and Fawcett (2013), digitalization ensures the transition from fragmented and reactive logistics systems to predictive, integrated, and data-driven models of supply chain management [8].

Empirical studies demonstrate that IoT-enabled real-time monitoring significantly reduces operational risks and cargo losses, improves visibility, and enhances customer satisfaction (Liu, Li & Wang, 2021) [9]. Similarly, research conducted by Kache and Seuring (2017) identifies the

strategic role of big data analytics in optimizing transportation routes, forecasting disruptions, and supporting sustainable logistics [10].

In the broader geopolitical context, digitalization is becoming a critical factor for the competitiveness of Eurasian transit corridors. Ivanov (2021), analyzing the evolution of Eurasian logistics routes, argues that digital ecosystems—comprising smart infrastructure, integrated data platforms, and predictive traffic analytics—are essential for ensuring stable cargo flows [11]. Makhmutova (2022) further emphasizes that Kazakhstan's participation in international transport initiatives requires the implementation of intelligent transport systems (ITS), harmonized digital standards, and integrated multimodal digital corridors [12].

International organizations also highlight the importance of digital transformation. The World Bank Logistics Performance Index (2023) [13] reveals a strong correlation between technological readiness and logistics efficiency, indicating that countries with advanced digital infrastructure exhibit higher cargo turnover and reduced transportation costs. Similarly, the OECD (2021) notes that digital logistics platforms increase agility, minimize uncertainties, and support competitiveness in global supply chains [14].

Despite substantial progress in international research, the academic literature on Kazakhstan's transport digitalization remains limited. Existing studies focus primarily on descriptive analyses of the country's transit potential (Akhmetova, 2020; Alimbayev, 2021), while quantitative assessments and empirical modeling of economic effects remain underdeveloped [15,16]. There is a notable absence of analytical frameworks evaluating the financial impact of digitalization on national logistics systems—particularly in the context of cost reduction, transit revenue growth, and warehouse optimization.

This gap underscores the necessity of the present research. The scientific contribution of this study lies in the development of a quantitative analytical model for estimating the economic benefits of digitalization and in providing an empirically grounded assessment of Kazakhstan's transport and logistics sector. The literature review thus confirms that while global studies provide a strong conceptual foundation, the specific context of Kazakhstan remains underexplored, creating a clear scientific niche for this research.

### **Materials and research methods.**

A characteristic feature of digitalization is its dynamic integration into everyday life, which enhances convenience and transforms traditional approaches to logistics. The expansion of information resources in the fields of transport, freight forwarding, logistics operations, road infrastructure management, public administration, and service provision within EU countries has significantly increased the awareness of customers regarding available services, suppliers, and service options.

The primary drivers behind the implementation of digital technologies in these domains are adaptive and self-organizing systems, which are capable not only of digitizing certain physical processes but also of generating recommendations and predicting possible situational developments. If previously the main priority for transport service users was the timely and safe delivery of goods, at present both consumers and businesses place greater emphasis on real-time monitoring of shipments, the condition of cargo, its current stage in the logistics cycle, potential delays, compliance with safety standards, as well as the availability of statistical data on transportation, handling, and delivery processes. The accumulation and analysis of such data enable the optimization of transport and logistics systems, ensuring greater efficiency and reliability.

The fulfillment of these growing requirements is directly linked to the continued digitalization of logistics processes. Global economic trends, including e-commerce, remote access, the Internet of Things, digital twins, cloud technologies, blockchain, robotic process automation, and big data analytics, contribute to the acceleration of digital transformation across industries, particularly in transport and logistics [3]. Among the most significant innovations are projects involving the development of intelligent transport systems, autonomous driving

technologies, unmanned vehicles, artificial intelligence applications, digital platforms, and drone-based delivery solutions.

Digital logistics today encompasses the collection, processing, storage, and transmission of information through advanced digital technologies, supporting demand forecasting, route optimization, and the effective management of material and information flows while reducing delays within supply chains. In this context, optimizing cargo delivery across distribution networks, from producer to consumer, has become an increasingly relevant objective.

The rapid pace of global development underscores the accelerating transformation of business processes in all sectors, with logistics playing a central role. Whereas in the early stages of logistics the consumer dictated requirements to producers, the modern situation demonstrates a more complex interaction: not only do consumers continue to shape expectations, but producers and carriers also actively seek innovative strategies to influence customer preferences and strengthen their competitive positions in the market.

The methodological basis of this study relies on a combination of quantitative, comparative, and analytical approaches aimed at identifying the economic and operational effects of digitalization in Kazakhstan's transport and logistics sector. The analysis is based on official statistics, World Bank and OECD datasets, as well as international benchmarks in logistics digital transformation.

To enhance the scientific rigor, an analytical model was introduced to quantify the potential economic effect of digitalization:

$$E_{\text{dig}} = (C_{\text{base}} - C_{\text{new}}) + R_{\text{add}} + S_{\text{opt}}$$

where:

$E_{\text{dig}}$  — total annual economic effect of digitalization (USD million);

$C_{\text{base}}$  — baseline logistics costs before digitalization;

$C_{\text{new}}$  — logistics costs after digital transformation;

$R_{\text{add}}$  — additional revenue from increased transit and logistics efficiency;

$S_{\text{opt}}$  — savings from optimization of warehouse and cargo processes.

This model allows for the quantitative evaluation of the impact of IoT, RFID, autonomous vehicles, and digital platforms on reducing logistics costs, improving operational transparency, and optimizing resource allocation. The research assumes an efficiency improvement of 10–15% based on global case studies.

Unlike previous descriptive studies, this research integrates empirical data and analytical modeling, providing measurable parameters for evaluating digital transformation efficiency

### **Results and their discussion.**

The digital transformation of the transport and logistics sector faces a number of systemic barriers that significantly slow down the pace of technological integration. Among the key challenges are the shortage of qualified personnel with advanced digital competencies, the high financial costs required for the implementation of digital solutions, the insufficient maturity of technology providers, as well as the presence of inefficient standards and regulatory frameworks that do not fully correspond to current market demands. These constraints limit the ability of companies to fully exploit the potential of digital innovations and reduce the overall competitiveness of the industry.

In this context, the use of Internet of Things (IoT) technologies is regarded as a highly promising direction for the modernization of logistics processes. IoT enables integration with cloud-based GPS systems, providing real-time monitoring of individual shipments and their condition. The application of Radio Frequency Identification (RFID) chips significantly increases the accuracy of cargo tracking, ensuring full control at all stages of transportation and storage. This technology minimizes the risks of losses, facilitates the prevention of damage or theft, and supports

climate control in storage facilities. Additionally, IoT solutions allow for the identification and assessment of traffic conditions, which contributes to the optimization of transport routes.

The implementation of IoT in logistics not only reduces freight transportation costs but also increases the transparency of operations, which is particularly important for companies developing distribution centers and expanding logistics services. In today's realities, such technological integration forms the basis for sustainable growth, competitiveness, and the digital resilience of Kazakhstan's transport and logistics industry.

The presented digital technologies represent the next stage of logistics digitalization in Kazakhstan. Each of them addresses specific challenges of the transport and logistics system: drones and unmanned vehicles improve delivery speed and reduce operational costs; 3D printing shortens supply chains and transforms the role of logistics companies from finished product distributors to raw material suppliers; augmented reality enhances the efficiency of cargo handling and accelerates decision-making processes (table 1). Together, these innovations form a technological foundation that enables Kazakhstan not only to reduce logistics costs but also to increase its global competitiveness as a transit hub.

Table 1 – Digital technologies in transport and logistics and their implementation results

№	Digital technology	Technology characteristics	Results after implementation
1	<b>Cargo delivery by drones</b>	<ul style="list-style-type: none"> <li>– Fast delivery of small cargoes.</li> <li>– High speed and delivery accuracy.</li> </ul>	<ul style="list-style-type: none"> <li>– Utilization by 3PL operators.</li> <li>– Shortening of the supply chain.</li> <li>– Reduction of transportation costs.</li> <li>– <i>Limitation:</i> lack of regulatory framework for air traffic safety, permitted drone size and weight.</li> </ul>
2	<b>3D printing</b>	<ul style="list-style-type: none"> <li>– Large-scale accessibility.</li> <li>– Cost reduction in the production of items from composite materials.</li> </ul>	<ul style="list-style-type: none"> <li>– Additive manufacturing expands the production process.</li> <li>– Supply chain reduction through on-demand “printing” of products and decreased finished goods inventory.</li> <li>– Logistics companies supply raw materials instead of finished products.</li> <li>– Possibility of 3D printing at delivery points.</li> <li>– <i>Result:</i> generation of additional profit.</li> </ul>
3	<b>Unmanned vehicles</b>	<ul style="list-style-type: none"> <li>– Rapid environmental adaptation.</li> <li>– Autonomous navigation without human intervention.</li> <li>– Advanced software algorithms.</li> </ul>	<ul style="list-style-type: none"> <li>– Reduced waiting time for loading/unloading operations.</li> <li>– Decreased risk of accidents.</li> <li>– <i>Result:</i> lowering of overhead costs.</li> </ul>
4	<b>Augmented Reality (AR)</b>	<ul style="list-style-type: none"> <li>– Ability to provide direct or indirect real-world visualization through additional computer-generated elements.</li> <li>– Expanded real-time perception of the environment.</li> </ul>	<ul style="list-style-type: none"> <li>– Detailed familiarization with cargo and its surroundings by logistics operators.</li> <li>– <i>Result:</i> improved cargo handling, increased delivery speed, and reduced overall logistics co</li> </ul>

Advantages of digitalization of transport logistics:

- New product development, more innovation;
- New sources of income;
- A more dynamic, secure and interactive supply chain;
- Improved response to market conditions;
- Accelerated planning and execution capabilities;
- Reduction of time to market;
- Improved access to real-time data and information;
- Better decision making;
- More flexible and efficient processes and operations;
- Increased control, visibility and collaboration;
- Better customer service and increased customer satisfaction.

The demand of transport and logistics for digital technologies in 2020 amounted to 1.2 billion US dollars, and by 2030 it may grow to 8.8 billion US dollars. Thanks to digital transformation, labor productivity in the industry will increase by 20% by 2030. The list of the most in-demand technologies includes paperless document management, distributed registry systems, wireless communications, and artificial intelligence, augmented and virtual reality. [5]

Transport (transportation) documents, formats and requirements for them differ significantly due to different regulations, tariff policies and other aspects of the development of individual modes of transport. Their synchronization and conversion into electronic form will greatly speed up the processes of processing, registration, control and traceability of goods.

The basis for the development of multimodal transport should be intelligent transport systems (ITS), which will ensure the interaction of the roadway, infrastructure facilities (traffic lights, video cameras, lighting systems, etc.), vehicles, applications for operational traffic management, etc. The key trend is the creation of unmanned vehicles based on artificial intelligence technologies, the emergence of smart roads, development of technologies for communication of cars with each other and with the road infrastructure.

In logistics, the rapid growth of e-commerce, including due to the pandemic, has led to an acceleration in the pace of end-to-end digitalization of supply chains and delivery, including using drones. The growing demand for digital platforms based on distributed ledger technologies, including blockchain, for transactions and freight clearance, the Internet of Things for tracking cargo movement, analytics for inventory management and predictive analytics for planning repairs and maintenance.

The rapid development of Internet technologies necessitates a flexible response in such a traditionally considered established industry as transport. Digitalization is erasing familiar boundaries, making business more and more cross-border. Currently, the level of digitalization of the transport and logistics services market can be described as "catching up". There are also positive aspects in this, which are the ability to avoid mistakes and use the experience of leaders.

At the same time, there are still opportunities for rapid restructuring of existing processes based on digitalization, which will allow us to take a worthy place in the global transport services market. Right now, the whole world is on the verge of a leap that will occur after the widespread use of digital technology, breakthrough technologies being developed.

Among those that can have the greatest impact are autonomous vehicles, 3–D printing, digital platforms, big data analytics, artificial intelligence, and drone delivery.

The introduction of digital technologies into Kazakhstan's transport and logistics system generates a significant economic effect by reducing costs, optimizing freight flows, and increasing transparency of operations. Based on scenario analysis (conservative, baseline, and optimistic), the potential annual benefit is estimated at USD 0.54–2.69 billion (table 2).

Table 2 – Economic effect of transport digitalization in Kazakhstan

Area of effect	Mechanism	Share in total savings	Potential savings (million USD per year)
Route optimization and fuel cost reduction	IoT, GPS, intelligent transport systems	~30%	162 – 807
Reduction of losses and theft	RFID, IoT sensors, digital cargo monitoring	~20%	108 – 538
Warehouse cost reduction	Automated accounting, climate control, smart warehouses	~25%	135 – 673
Efficiency of transport operations	Telematics, predictive maintenance	~15%	81 – 404
Other effects (downtime reduction, digital document flow)	Digital platforms, blockchain solutions	~10%	54 – 269
<b>Total</b>	–	<b>100%</b>	<b>540 – 2,690</b>

The main areas of savings are related to route optimization and fuel efficiency, prevention of losses and theft, warehouse cost reduction, enhanced efficiency of transport operations, and additional effects such as downtime reduction and automation of document flow.

The results of the analysis demonstrate that the largest share of the effect comes from route optimization and fuel cost reduction ( $\approx 30\%$ ), followed by warehouse cost reduction ( $\approx 25\%$ ) and prevention of losses and theft ( $\approx 20\%$ ). The remaining share is attributed to operational efficiency ( $\approx 15\%$ ) and other effects ( $\approx 10\%$ ).

Thus, digitalization not only reduces direct financial and time costs, but also contributes to the long-term competitiveness of Kazakhstan as a key Eurasian transit hub.

The analysis of the economic impact of digitalization in Kazakhstan's transport and logistics sector demonstrates significant potential for cost reduction and efficiency improvement. Based on expert assessments and statistical data [2,9], the introduction of IoT systems, digital platforms, and unmanned technologies could generate the following effects:

1. Reduction of transportation costs
  - Current logistics costs in Kazakhstan account for approximately 15% of GDP.
  - With digitalization (automation, IoT monitoring, predictive analytics), costs could be reduced by 10–12%.
    - This corresponds to an estimated savings of USD 1.2–1.4 billion annually.
2. Decrease in cargo losses and theft
  - According to national statistics, losses in cargo transportation average 1.5% of cargo value.
    - Implementation of RFID and IoT tracking can reduce this figure to 0.5%.
    - For an annual cargo turnover of USD 50 billion, potential savings amount to USD 500 million.
3. Improvement in transit efficiency
  - Transit cargo flows through Kazakhstan exceed 20 million tons per year.
  - Implementation of intelligent transport systems and digital corridors can reduce average delivery time by 15–20%.
    - This effect strengthens Kazakhstan's competitiveness in Eurasian transit corridors, potentially increasing annual transit revenues by USD 300–400 million.
4. Optimization of warehouse operations

- Digital warehouse management systems (WMS) can reduce storage costs by 15%.
- Considering that warehousing accounts for ~25% of logistics costs, the potential annual savings are USD 200–250 million.

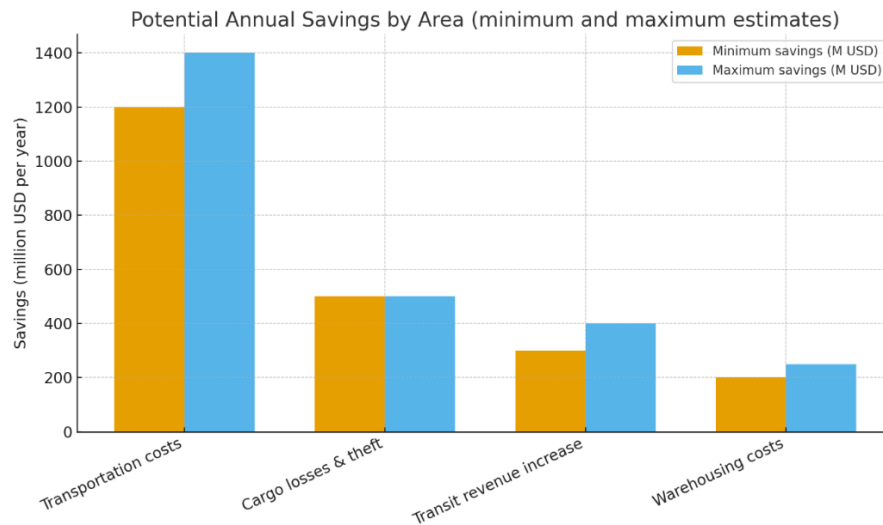


Figure 1 – Potential annual savings by area (minimum and maximum estimates), million USD

The figure 1 illustrates the potential savings by category, showing both minimum and maximum estimates. The most significant contribution comes from the reduction of transportation costs (USD 1.2–1.4 billion), followed by decreased cargo losses through RFID and IoT monitoring (USD 0.5 billion). Additional benefits are achieved through improved transit revenue (USD 300–400 million) and warehouse optimization (USD 200–250 million).

Share of Total Estimated Savings (midpoint estimates)

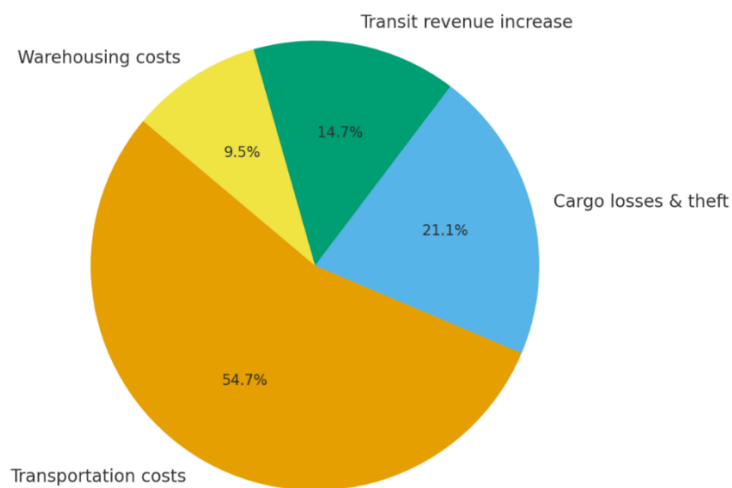


Figure 2 – Share of total estimated savings (midpoint estimates), %

The figure 2 presents the relative share of savings across categories. Transportation cost reduction accounts for almost 55% of the total effect, while cargo loss prevention contributes around 20–23%. Transit efficiency and warehousing optimization together account for another

25%, highlighting the importance of comprehensive digital transformation across multiple logistics domains.

Applying the analytical model, the estimated annual economic effect of digitalization in Kazakhstan's transport and logistics sector ranges from USD 2.2 to 2.5 billion, or about 2% of the national GDP (tabl 3). This effect is derived from the following key factors:

Table 3 - Summary of Digitalization Benefits in Kazakhstan's transport and logistics sector

Indicator	Current level	With digitalization	Potential savings (USD million)
Transportation costs	15% of GDP (~USD 12 bn)	13–13.5% of GDP	1,200–1,400
Cargo losses/theft	1.5% of cargo value (~USD 750 m)	0.5% (~USD 250 m)	500
Transit revenue	USD 2 bn annually	+15–20% growth	300–400
Warehousing costs	~USD 1.5 bn annually	–15%	200–250
Total potential savings	–	–	~2.2–2.5 bn per year

The obtained results demonstrate the clear interdependence between technological readiness and logistics efficiency, confirming that targeted investment in digital infrastructure directly contributes to national economic competitiveness.

These calculations confirm that the largest contribution comes from the reduction of transportation costs and prevention of cargo losses through the use of IoT sensors, GPS tracking, and RFID technologies. Transit efficiency and warehousing optimization account for additional savings, strengthening Kazakhstan's position as a logistics hub in Eurasia.

The introduction of digital tools such as blockchain-based platforms and predictive analytics increases transparency, reduces delays, and enhances service quality. The integration of these systems contributes to operational sustainability, improved coordination among logistics operators, and cost-effectiveness.

However, the potential economic benefits can be fully realized only by addressing systemic challenges, including the high cost of digital investments, shortage of qualified specialists, and regulatory limitations regarding unmanned technologies. Overcoming these barriers will require government support, educational reforms, and public–private collaboration to foster digital innovation.

Digital logistics today represents a key factor in the transformation of transport and logistics systems, as it directly contributes to reducing time, labor, and financial losses associated with data collection, processing, and analysis. Through the use of digital technologies, it becomes possible to design optimal business interaction models that are based on advanced methods of production, economic, and trade-economic relations among different institutional actors. The integration of such approaches ensures the development of adaptive supply chains, strengthens resilience to external challenges, and provides a foundation for sustainable competitiveness in both national and international markets.

The development of digital freight logistics in cargo transportation allows organizations to optimize the entire transport process, beginning with planning and continuing through monitoring, delivery, and distribution. Digital tools reduce the costs of organizing transportation activities, improve route planning, and ensure efficient resource allocation. Moreover, the digitalization of logistics operations significantly increases transparency, which is essential for building trust between stakeholders and enhancing the predictability of cargo flows.

For Kazakhstan, the expansion of knowledge and competencies in digital logistics is particularly relevant within the framework of creating a modern, efficient, and globally integrated transport and logistics system. This involves improving operational efficiency across all modes of transport, providing a wide range of high-quality services, and ensuring competitive tariff policies. An important direction is the modernization and systematic use of international transport corridors, where transparent timelines, predictable costs, and linearity of operations must be clearly established.

In addition, the strategic task is to create favorable infrastructure and organizational conditions for the processing of incoming and outgoing cargo flows with their subsequent local distribution to final destinations. This includes the development of logistics hubs, smart warehouses, and digital platforms for coordination and control. The consistent implementation of these measures will allow Kazakhstan not only to strengthen its transit potential but also to establish itself as a key logistics hub in the Eurasian transport space, ensuring the sustainable growth of trade and industrial cooperation.

### **Conclusion.**

The research findings confirm that digital technologies serve as a key driver for the modernization of Kazakhstan's transport and logistics system. The implementation of innovations such as IoT, drones, unmanned vehicles, augmented reality, and 3D printing significantly reduces transportation costs, increases transparency, and minimizes operational risks. Furthermore, the adoption of digital platforms improves the efficiency of supply chains and creates favorable conditions for strengthening Kazakhstan's role as a Eurasian transit hub.

Nevertheless, the study also reveals persistent barriers, including insufficient human capital development, high costs of technological transformation, low maturity of domestic digital solution providers, and regulatory gaps. Overcoming these challenges requires coordinated state policy, investment in digital infrastructure, and active participation of private sector stakeholders.

In conclusion, digital transformation should be viewed not only as an economic necessity but also as a strategic imperative for Kazakhstan's sustainable development. Systematic adoption of advanced technologies will enable the country to enhance its competitiveness, improve the efficiency of logistics operations, and solidify its position in global transport and supply chain networks.

The findings of this study demonstrate that the digital transformation of Kazakhstan's transport and logistics sector has the potential to generate substantial economic and operational benefits. By integrating advanced technologies such as IoT, RFID, autonomous transport, and digital platforms, the industry can reduce transportation costs, minimize cargo losses, optimize warehousing operations, and increase transit revenues. The estimated cumulative effect of digitalization could reach USD 2.2–2.5 billion annually, representing nearly 2% of Kazakhstan's GDP, which underlines the strategic importance of this transformation.

At the same time, the research highlights critical barriers that may limit the scale of digital adoption, including the high cost of financing, insufficient digital competencies among personnel, and the absence of clear regulatory and standardization frameworks. These challenges indicate that digitalization is not solely a technological issue but also an institutional and organizational task requiring systemic coordination.

The results of this study clearly demonstrate that digitalization has the potential to generate significant economic benefits for Kazakhstan's transport and logistics sector, estimated at USD 2.2–2.5 billion annually. However, the realization of this effect is not automatic and depends on the ability to overcome structural and institutional barriers.

First, the high cost of financing digital transformation remains a key challenge. While the long-term savings are considerable, many logistics operators—especially small and medium-sized enterprises—lack the investment capacity to implement IoT, RFID, or cloud-based systems at scale. Public–private partnerships and state support mechanisms are therefore crucial to accelerate digital adoption.

Second, the shortage of qualified personnel in digital logistics and data-driven transport management limits the pace of transformation. Without investment in human capital—through targeted educational programs, professional training, and university–industry collaboration—the technological potential will not translate into operational efficiency.

Third, regulatory and standards-related inefficiencies constrain innovation. For instance, the absence of clear legislation for unmanned vehicles or drone-based cargo delivery prevents these technologies from moving beyond pilot projects. Similarly, fragmented standards for digital data exchange reduce interoperability between logistics operators.

As well as, while the economic potential is clear, the effective implementation of digitalization in Kazakhstan’s transport and logistics sector requires a systemic approach:

1. mobilizing investment resources;
2. strengthening digital competencies;
3. developing coherent regulatory frameworks.

Only by addressing these barriers will Kazakhstan be able to fully leverage digital technologies to strengthen its transit potential and secure a competitive position in the global logistics network.

Future research should focus on developing predictive econometric models for quantifying the long-term effects of digital transformation on Kazakhstan’s logistics performance and transit capacity.

Therefore, the effective realization of digital potential requires a comprehensive national strategy that combines public–private partnerships, investment in human capital, and harmonization of digital standards. Only under these conditions will Kazakhstan be able to strengthen its role as a competitive Eurasian transit hub and ensure the sustainable development of its transport and logistics system in the era of digital economy.

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#### **ЦИФРЛЫҚ ТЕХНОЛОГИЯЛАРДЫҢ ҚАЗАҚСТАНДАҒЫ КӨЛІКТІК ЛОГИСТИКАНЫ ДАМУҒА ӘСЕРІ**

*Аңдатпа.* Мақалада цифрлық логистиканы зерделеумен және Қазақстанның көлік-логистика секторына заманауи технологияларды енгізу дәрежесін талдаумен байланысты мәселелер қаралады. Зерттеу технологиялық дайындық, инновациялық даму және логистиканың тиімділігі арасындағы өзара байланысты бағалауға негізделген. 1990 жылдардың соңынан бастап, алғаш рет интернет-технологиялар мен цифрлық экономика тұжырымдамалары кеңінен талқылана бастаған кезде, бизнес-процестер мен тұтыну практикаларын түбегейлі өзгерткен елеулі өзгерістер болды. Екі оннан астам жылда цифрландыру көлік логистикасының бәсекеге қабілеттілігі мен тиімділігінің маңызды факторына айналды. Бүгінде цифрландыру инновациялық құбылыс ретінде қабылданбайды, ол саланы дамытудың нормативтік стандарты болып саналады. Электрондық билеттер, жолаушыларды онлайн-тіркеу жүйелері, сандық навигациялық платформалар және таксиге арналған мобильді қосымшалар тәжірибелік мысалдар болып табылады. Бір кездері қол жеткізе алмайтындай болып көрінетін бұл технологиялар енді күнделікті логистикалық операциялар мен тұтынушылық практикаларға біріктірілді. Сонымен қатар жалғасып жатқан цифрлық трансформация пилотсыз көлік құралдары, жол қозғалысын басқарудың зияткерлік жүйелері және жол қозғалысы ережелерінің сақталуын бақылауға қабілетті зияткерлік көлік инфрақұрылымы сияқты озық шешімдерді енгізуге барған сайын көбірек бағдарланған.

Цифрлық платформалар логистикалық тізбектердің ашықтығын, қолжетімділігі мен тиімділігін қамтамасыз ете отырып, қазіргі заманғы жаһандық экономиканың іргетасына айнауда. Олардың рөлі Қазақстанның көліктік-логистикалық жүйесінің жаһандық жеткізу тізбегіне ықпалдасуын тереңдету үшін ерекше маңызды, бұл орнықты экономикалық дамуға және елдің транзиттік әлеуетін нығайтуға ықпал етеді.

**Түйін сөздер:** цифрлық логистика, цифрландыру, инновациялар, көлік инфрақұрылымы, жүк тасымалы.

## ВЛИЯНИЕ ЦИФРОВЫХ ТЕХНОЛОГИЙ НА РАЗВИТИЕ ТРАНСПОРТНОЙ ЛОГИСТИКИ В КАЗАХСТАНЕ

**Аннотация.** В статье рассматриваются вопросы, связанные с изучением цифровой логистики и анализом степени внедрения современных технологий в транспортно-логистическом секторе Казахстана. Исследование основано на оценке взаимосвязи между технологической готовностью, инновационным развитием и эффективностью логистики. С конца 1990-х годов, когда впервые стали широко обсуждаться концепции интернет-технологий и цифровой экономики, произошли значительные трансформации, кардинально изменившие бизнес-процессы и потребительские практики. За два с лишним десятилетия цифровизация превратилась в важнейший фактор конкурентоспособности и эффективности транспортной логистики. Сегодня цифровизация уже не воспринимается как инновационное явление, а считается нормативным стандартом развития отрасли. Практическими примерами являются электронные билеты, системы онлайн-регистрации пассажиров, цифровые навигационные платформы и мобильные приложения для такси. Эти технологии, которые когда-то казались недостижимыми, теперь интегрированы в повседневные логистические операции и потребительские практики. В то же время продолжающаяся цифровая трансформация все больше ориентирована на внедрение передовых решений, таких как беспилотные транспортные средства, интеллектуальные системы управления дорожным движением и интеллектуальная транспортная инфраструктура, способная контролировать соблюдение правил дорожного движения.

Цифровые платформы становятся краеугольным камнем современной глобальной экономики, обеспечивая прозрачность, доступность и эффективность логистических цепочек. Их роль особенно важна для углубления интеграции транспортно-логистической системы Казахстана в глобальные цепочки поставок, что способствует устойчивому экономическому развитию и укреплению транзитного потенциала страны.

**Ключевые слова:** цифровая логистика, цифровизация, инновации, транспортная инфраструктура, грузовые перевозки.

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